SSL1523A

SMPS ICs for mains LED drivers

Rev. 1 — 25 April 2012 | Product data sheet

1. General description

The SSL1523A is a Switched Mode Power Supply (SMPS) controller IC that operate directly from the rectified universal AC mains. It is implemented in the high-voltage Easy High Voltage Silicon-On-Insulator (EZ-HV SOI) process, combined with a low-voltage Bipolar Complementary Metal Oxide Semiconductor (BiCMOS) process. The device includes a high-voltage power switch and a start-up circuit that operates directly from the rectified mains voltage.

A dedicated circuit for valley switching is built in, which makes a very efficient slim-line electronic concept for solid state lighting applications possible.

The SSL1523A can operate in applications with a power range of up to 15 W.

In the most basic applications, the SSL1523A act as a voltage source. Here, no additional secondary electronics are required. A combined voltage and current source can be realized with minimum costs for external components. Implementation of the SSL1523A renders an efficient and low cost power supply system for mains LED drivers.

2. Features and benefits

- Designed for mains LED drivers up to 15 W
- Integrated power switch: 6.5 Ω; 650 V
- Operates from universal AC mains supplies (80 V to 276 V)
- Adjustable frequency for flexible design
- RC oscillator for load insensitive regulation loop constant
- Valley switching for minimum switch-on loss
- Low standby power (< 100 mW) with frequency reduction at low power outputs
- Adjustable overcurrent protection
- Undervoltage protection
- Temperature protection
- Simple application with both primary and secondary (opto) feedback
- Available in a DIP8 package

3. Applications

- Retro-fit LED lamps
- LED ballasts
- Contour lighting
- Channel letter lighting
- Commercial lighting, such as cabinet or freezer lights
- Other lighting applications

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DRAIN}	voltage on pin DRAIN	DMOS power transistor; $T_j > 0$ °C	–0.4	-	+650	V
R_{DSon}	drain-source on-state resistance	$I_{source} = -0.50$ A				
		$T_j = 25$ °C	-	6.5	7.5	Ω
		$T_j = 100$ °C	-	9.0	10.0	Ω
V_{CC}	supply voltage	continuous	–0.4	-	+40	V
f_{osc}	oscillator frequency		10	100	200	kHz
I_{DRAIN}	current on pin DRAIN	$V_{DRAIN} > 60$ V				
		no auxiliary supply	-	1.5	2	mA
		with auxiliary supply	-	30	125	μA

5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
SSL1523AP	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1

6. Block diagram

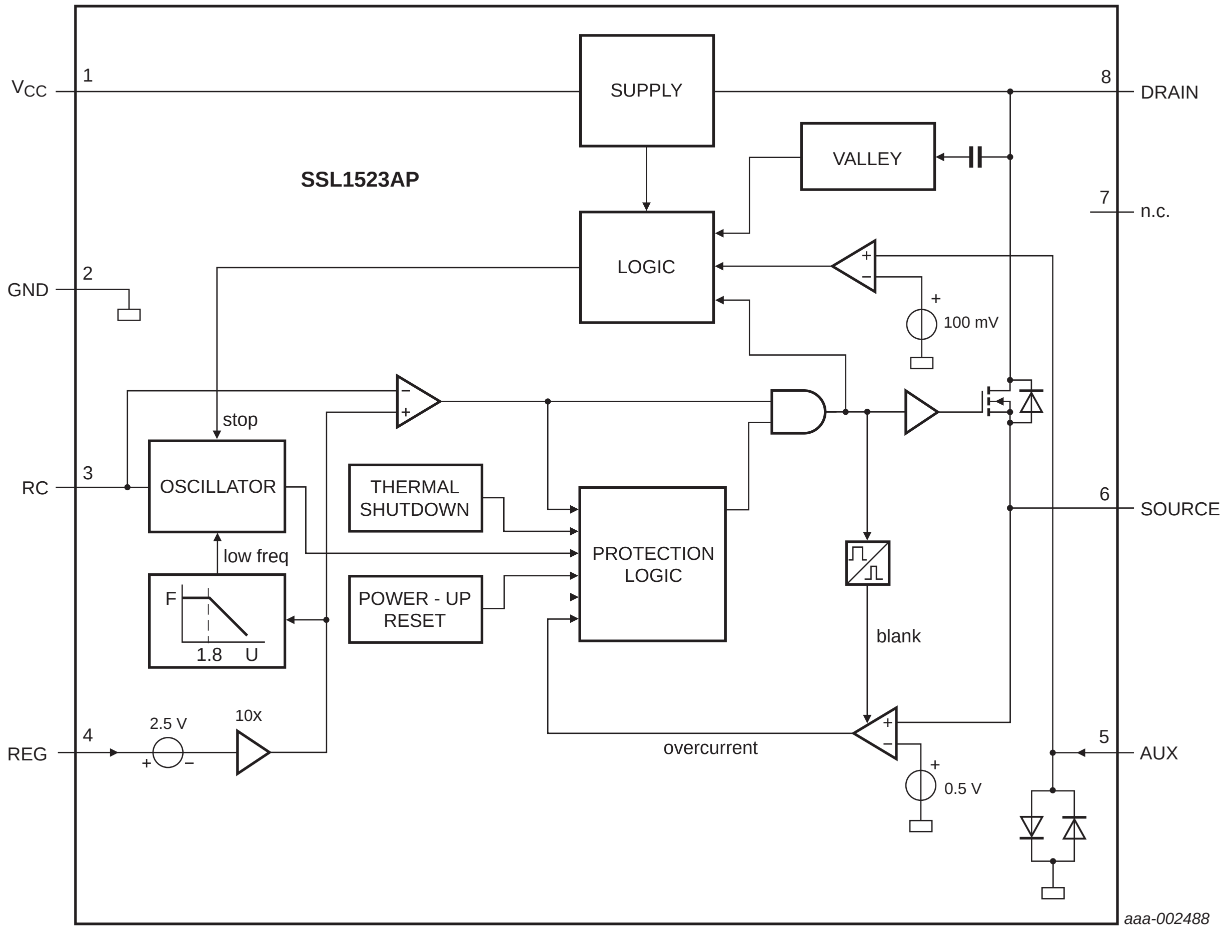


Fig 1. Block diagram

7. Pinning information

7.1 Pinning

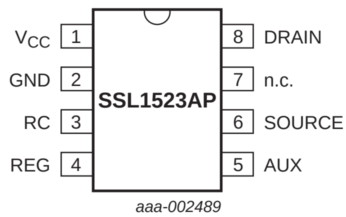


Fig 2. Pinning diagram (DIP8)

7.2 Pin description

Table 3. Pin description

Symbol	Pin (DIP8)	Description
V_{CC}	1	supply voltage
GND	2	ground
RC	3	frequency setting
REG	4	regulation input
AUX	5	input for voltage from auxiliary winding for timing (demagnetization)
SOURCE	6	source of internal MOS switch
n.c.	7	not connected
DRAIN	8	drain of internal MOS switch; input for start-up current and valley sensing

8. Functional description

The SSL1523A is the heart of a compact flyback converter, with the IC placed at the primary side. The auxiliary winding of the transformer can be used for indirect feedback to control the isolated output. This additional winding also powers the IC. A more accurate control of the output voltage and/or current can be implemented with an additional secondary sensing circuit and optocoupler feedback.

The SSL1523A uses voltage mode control. The switching frequency is determined by the maximum transformer demagnetizing time and the frequency of the oscillator. In the first case, the converter operates in the Self Oscillating Power Supply (SOPS) mode. In the latter case, it operates at a constant frequency, which can be adjusted with external components R_{RC} and C_{RC}. Furthermore, a primary stroke is started only in a valley of the secondary ringing. This can use constant power or constant current mode to drive LEDs. The valley switching principle minimizes capacitive switch-on losses.

8.1 Start-up and undervoltage lockout

Initially, the IC is self-supplying from the rectified mains voltage. The IC starts switching as soon as the voltage on pin V_{CC} passes the $V_{CC(startup)}$ level. The supply is taken over by the auxiliary winding of the transformer as soon as V_{CC} is high enough and the supply from the line is stopped for high efficiency operation.

If the auxiliary supply is not sufficient, the high-voltage supply also supplies the IC. As soon as the voltage on pin V_{CC} drops below the $V_{CC(stop)}$ level, the IC stops switching and restarts from the rectified mains voltage.

8.2 Oscillator

The frequency of the oscillator is set by the external resistor and capacitor on pin RC. The external capacitor is charged rapidly to the $V_{RC(max)}$ level and, starting from a new primary stroke, it discharges to the $V_{RC(min)}$ level. Because the discharge is exponential, the relative sensitivity of the duty factor to the regulation voltage at low duty factor is almost equal to the sensitivity at high duty factors. This results in a more constant gain over the duty factor range compared to systems with a linear sawtooth oscillator. Stable operation at low duty factors is easily realized. For high efficiency, the frequency is reduced as soon as the duty factor drops below its low power threshold. This is accomplished by increasing the oscillator charge time.

To ensure that the capacitor can be charged within the charge time, the value of the oscillator capacitor should be limited to approximately 1 nF.

8.3 Duty factor control

The duty factor is controlled by the internal regulation voltage and the oscillator signal on pin RC. The internal regulation voltage is equal to the external regulation voltage (minus 2.5 V) multiplied by the gain of the error amplifier (typically 20 dB).

8.4 Valley switching

A new cycle is started when the primary switch is switched on (see Figure 3). After a certain time (determined by the oscillator voltage RC and the internal regulation level), the switch is turned off and the secondary stroke starts. The internal regulation level is determined by the voltage on pin REG.

After the secondary stroke, the drain voltage shows an oscillation with a frequency approximately equal to the value given by Equation 1:

$$\frac{1}{2 \times \pi \times \sqrt{(L_p \times C_p)}} \qquad (1)$$

where:

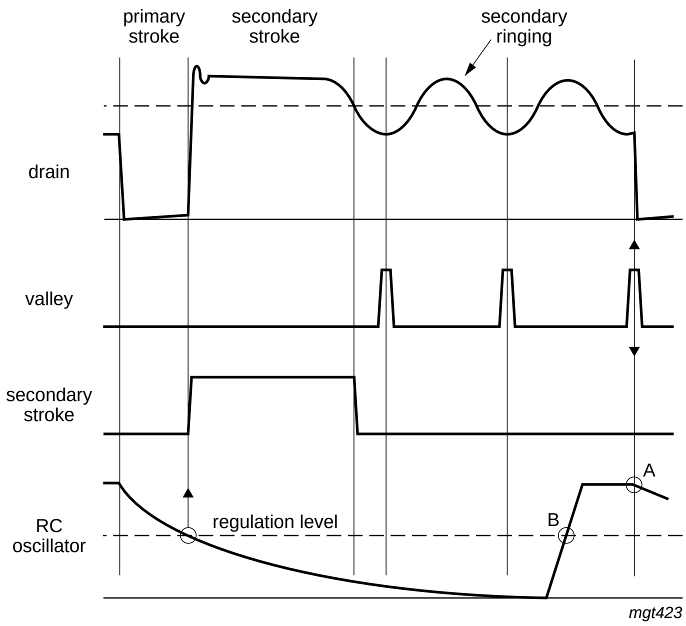
L_p = primary self-inductance

C_p = parasitic capacitance on drain node

As soon as the oscillator voltage becomes high again and after the secondary stroke has ended, the circuit waits for a low drain voltage before starting a new primary stroke.

Figure 3 shows the drain voltage together with the valley signal, the signal indicating the secondary stroke and the RC voltage.

The primary stroke starts some time before the actual valley at low ringing frequencies, and some time after the actual valley at high ringing frequencies.



A: Start of new cycle with valley switching.

B: Start of new cycle in a classical system.

Fig 3. Signals for valley switching

Figure 4 shows a typical curve for a reflected output voltage N × V_o of 80 V. This voltage is the output voltage V_o (see Figure 5) transferred to the primary side of the transformer with the factor N (determined by the turns ratio of the transformer). Figure 4 shows that the system switches at the minimum drain voltage for ringing frequencies of 480 kHz, thus reducing the switch-on losses to a minimum. At 200 kHz, the next primary stroke is started at 33 ° before the valley. The switch-on losses are still reduced significantly.

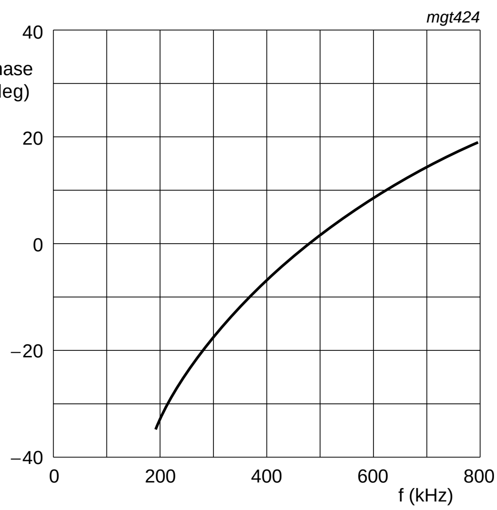


Fig 4. Typical phase of drain ringing at switch-on (at N × V_o = 80 V)

8.5 Demagnetization

The system operates in discontinuous conduction mode all the time. As long as the secondary stroke has not ended, the oscillator will not start a new primary stroke. During the first $t_{sup(xfmr\_ring)}$ seconds, demagnetization recognition is suppressed. This suppression may be necessary in applications where the transformer has a large leakage inductance and at low output voltages.

8.6 Minimum and maximum duty factor

The minimum duty factor of the switched mode power supply is 0 %. The maximum duty factor is set to 75 % (typical value at 100 kHz oscillation frequency).

8.7 OverCurrent Protection (OCP)

The cycle-by-cycle peak drain current limit circuit uses the external source resistor R_I to measure the current. The circuit is activated after the leading edge blanking time t_{leb}. The protection circuit limits the source voltage to $V_{SOURCE(max)}$ and thus limits the primary peak current.

8.8 OverTemperature Protection (OTP)

An accurate temperature protection is provided in the device. When the junction temperature exceeds the thermal shutdown temperature, the IC stops switching. During thermal protection, the IC current is lowered to the start-up current. The IC continues normal operation as soon as the overtemperature situation has disappeared.

8.9 OverVoltage Protection (OVP)

Overvoltage protection can be achieved in the application by pulling pin REG above its normal operation level. The current primary stroke is terminated immediately. No new primary stroke is started until the voltage on pin REG drops to its normal operation level. Pin REG has an internal clamp. The current feed into this pin must be limited.

8.10 Characteristics of complete LED power supply

8.10.1 Input

The input voltage range comprises the universal AC mains from 80 V to 276 V.

8.10.2 Accuracy

The accuracy of the complete converter, functioning as a voltage source with primary sensing, is approximately 8 % (mainly dependent on the transformer coupling). The accuracy with secondary sensing is defined by the accuracy of the external components. For safety requirements in case of optocoupler feedback loss, the primary sensing remains active when an overvoltage circuit is connected.

8.10.3 Efficiency

An efficiency over 80 % at maximum output power can be achieved for a complete converter designed for universal mains.

8.10.4 Ripple

A minimum ripple is obtained in a system designed for a maximum duty factor of 50 % under normal operating conditions and a minimized dead time. The magnitude of the ripple in the output voltage is determined by the frequency and duty factor of the converter, the output current level, and the value and Equivalent Series Resistance (ESR) of the output capacitor.

8.10.5 Output

The SSL1523A can operate over a wide range of output power levels up to 15 W.

9. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). All voltages are measured with respect to ground; positive currents flow into the device; pins V_{CC} and RC are not allowed to be current driven and pins REG and AUX are not allowed to be voltage driven.

Symbol	Parameter	Conditions		Min	Max	Unit
Voltage						
V_{CC}	supply voltage	continuous		–0.4	+40	V
V_{RC}	voltage on pin RC	oscillator input voltage		–0.4	+3	V
V_{SOURCE}	voltage on pin SOURCE	DMOS power transistor		–0.4	+5	V
V_{DRAIN}	voltage on pin DRAIN	DMOS power transistor; $T_j > 0$ °C		–0.4	+650	V
Current						
I_{REG}	current on pin REG			-	6	mA
I_{AUX}	current on pin AUX			–10	+5	mA
I_{source}	source current			–2	+2	A
I_{DRAIN}	current on pin DRAIN			–2	+2	A
General						
P_{tot}	total power dissipation	$T_{amb} < 45$ °C		-	1.0	W
T_{stg}	storage temperature			–55	+150	°C
T_j	junction temperature			–40	+145	°C
V_{ESD}	electrostatic discharge voltage	human body model	[1]	-	±2500	V
		machine model	[2]	-	±200	V

[1] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor. All pins are 2500 V maximum, except pin DRAIN, which is 1000 V maximum.

[2] Machine model: equivalent to discharging a 200 pF capacitor through a 0.75 μH coil and a 10 Ω series resistor.

10. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions		Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	100	K/W

[1] Thermal resistance $R_{th(j-a)}$ can be lower when the GND pins are connected to sufficient copper area on the printed-circuit board. See the SSL152x application notes for details.

11. Characteristics

Table 6. Characteristics

Measurement data valid at T_{amb} = 25 °C; no overtemperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply						
$I_{CC(oper)}$	operating supply current	normal operation	-	1.3	1.9	mA
$I_{CC(startup)}$	start-up supply current	start-up	-	180	400	µA
I_{CC}	supply current	V_{DRAIN} > 60 V	–6	–4	–3	mA
$V_{CC(startup)}$	start-up supply voltage		9	9.5	10	V
$V_{CC(stop)}$	stop supply voltage	undervoltage lockout	7.0	7.5	8.0	V
I_{DRAIN}	current on pin DRAIN	V_{DRAIN} > 60 V				
		no auxiliary supply	-	1.5	2	mA
		with auxiliary supply	-	30	125	µA
Pulse-width modulator						
δ_{min}	minimum duty factor		-	0	-	%
δ_{max}	maximum duty cycle	f = 100 kHz	-	75	-	%
SOPS						
$V_{det(demag)}$	demagnetization detection voltage		50	100	150	mV
$t_{sup(xfmr\_ring)}$	transformer ringing suppression time		1.0	1.5	2.0	µs
RC oscillator						
$V_{RC(min)}$	minimum voltage on pin RC		60	75	90	mV
$V_{RC(max)}$	maximum voltage on pin RC		2.4	2.5	2.6	V
t_{ch}	charge time		-	1	-	µs
f_{osc}	oscillator frequency		10	100	200	kHz
Duty factor regulator: pin REG						
V_{REG}	voltage on pin REG		2.4	2.5	2.6	V
G_v	voltage gain		-	20	-	dB
$V_{clamp(REG)}$	clamp voltage on pin REG	I_{REG} = 6 mA	-	-	7.5	V
Valley switching						
$(\Delta V/\Delta t)_{vrec}$	valley recognition voltage change with time		–102	-	+102	V/µs
f_{ring}	ringing frequency	$N \times V_o$ = 100 V	200	550	800	kHz
$t_{d(vrec-swon)}$	valley recognition to switch-on delay time		-	150	-	ns
Current protection						
$V_{SOURCE(max)}$	maximum voltage on pin SOURCE	$\Delta V/\Delta t$ = 0.1 V/µs	0.47	0.50	0.53	V
t_d	delay time	$\Delta V/\Delta t$ = 0.5 V/µs	-	160	185	ns
t_{leb}	leading edge blanking time		250	350	450	ns
FET output stage						
$I_{L(DRAIN)}$	leakage current on pin DRAIN	V_{DRAIN} = 650 V	-	-	125	µA
$V_{BR(DRAIN)}$	breakdown voltage on pin DRAIN	T_j > 0 °C	650	-	-	V

Table 6. Characteristics *…continued*

Measurement data valid at T_{amb} = 25 °C; no overtemperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R_{DSon}	drain-source on-state resistance	I_{source} = –0.50 A				
		T_j = 25 °C	-	6.5	7.5	Ω
		T_j = 100 °C	-	9.0	10.0	Ω
$t_{f(DRAIN)}$	fall time on pin DRAIN	V_i = 300 V; no external capacitor at drain	-	75	-	ns
Temperature protection						
T_{prot}	protection temperature		150	160	170	°C
$T_{prot(hys)}$	hysteresis of protection temperature		-	2	-	°C

12. Application information

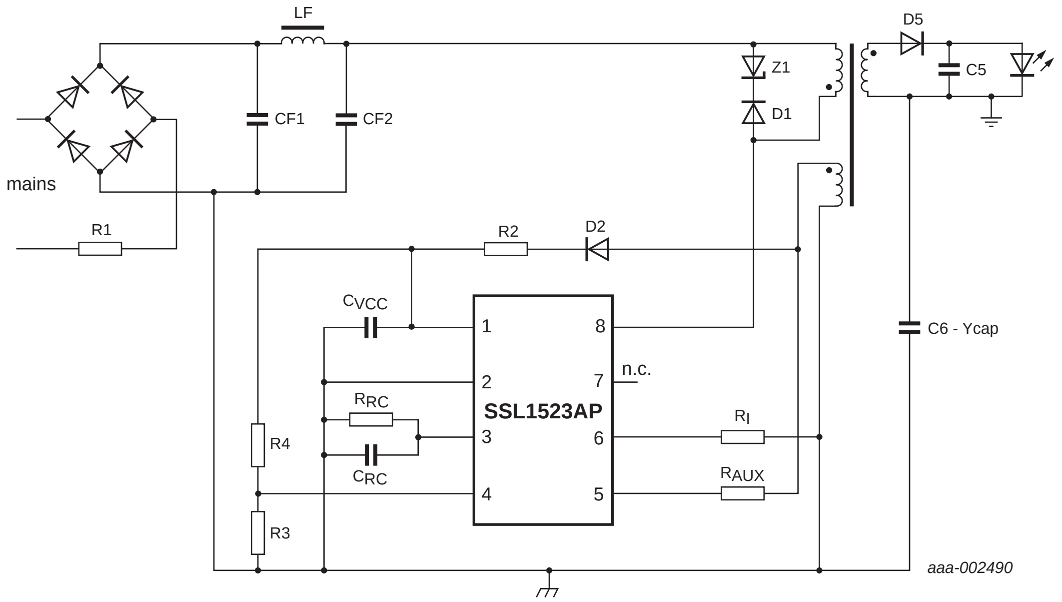
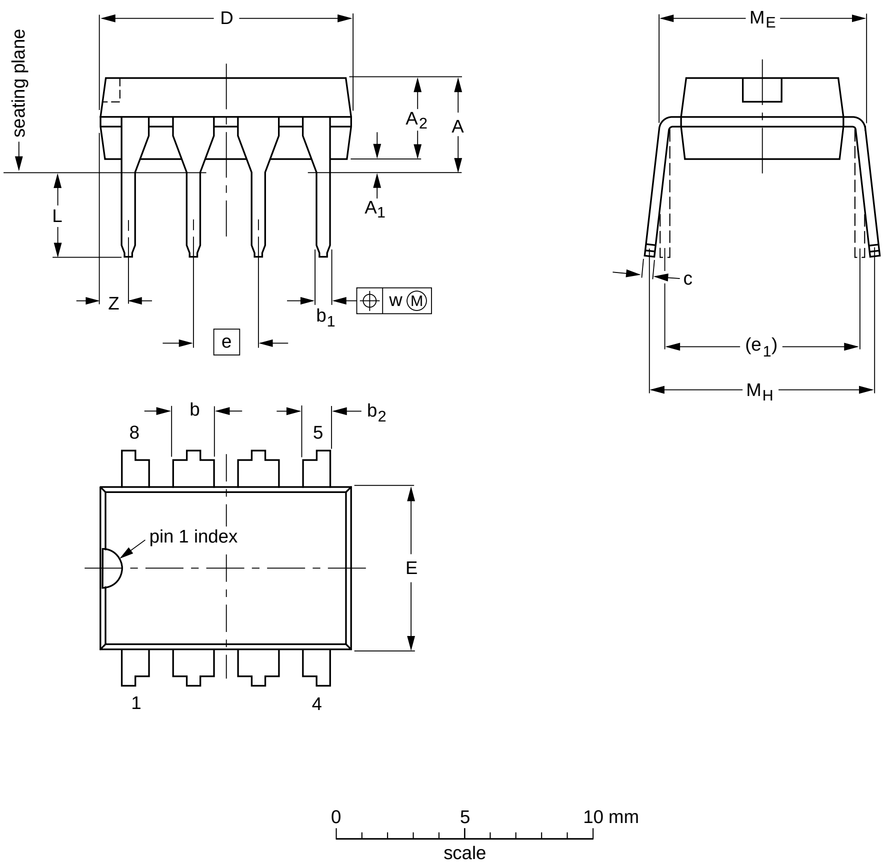


Fig 5. Typical configuration of SSL1523A - primary sensing

13. Package outline

DIP8: plastic dual in-line package; 8 leads (300 mil) **SOT97-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	b_2	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.02	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT97-1	050G01	MO-001	SC-504-8			~~99-12-27~~ 03-02-13

Fig 6. Package outline SOT97-1 (DIP8)

14. Abbreviations

Table 7. Abbreviations

Acronym	Description
BiCMOS	Bipolar Complementary Metal Oxide Semiconductor
DMOS	Diffusion Metal Oxide Semiconductor
ESR	Equivalent Series Resistance
EZ-HV SOI	Easy High Voltage Silicon-On-Insulator
FET	Field-Effect Transistor
SMPS	Switched Mode Power Supply
SOPS	Self-Oscillating Power Supply

15. Revision history

Table 8. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SSL1523A v.1	20120425	Product data sheet	-	-

16. Legal information

16.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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18. Contents

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